Tibial Bone Grafting for Wrist Reconstruction

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Abstract

Background Iliac crest bone graft harvesting is routinely performed for upper extremity orthopedic procedures despite high complication rates associated with sensory nerve injury, hematoma, chronic pain, and fracture.

Description of Technique Cancellous bone graft is harvested from the proximal tibia using a medial approach, minimizing donor site morbidity.

Patients and Methods A retrospective review was undertaken of 14 patients who underwent cancellous proximal tibia bone graft harvesting to augment healing of wrist reconstruction, with 2 months minimum follow-up. We report donor limb tourniquet time, time to union, visual analog scale (VAS) pain score, and complications. Patients were also contacted by phone to administer a retrospective questionnaire and record experiences with the harvesting technique.

Results Average donor site VAS for the immediate postoperative period was 7.4. Average tourniquet time was 28 minutes. Average time to union of the recipient site was 45 days. One patient experienced delayed union after corrective osteotomy, attributed to osteoporosis. Two patients underwent hardware removal from the operative wrist, unrelated to bone graft harvesting. One patient with a history of chronic neuropathy and foot drop developed dysesthesia and allodynia about the ipsilateral ankle, but was asymptomatic at the proximal tibia donor site; ankle symptoms resolved 3 weeks postoperatively. No patient reported any residual donor site difficulties 24.2 months postoperatively.

Conclusion In consideration of the minimal complication rate, favorable clinical parameters, and excellent patient tolerance, we advocate proximal tibia bone graft harvesting as opposed to iliac crest harvesting for wrist reconstruction when a moderate amount of autogenous cancellous graft is needed.

Level of Evidence IV.

Keywords
- bone graft
- proximal tibia
- complications
- distal radius malunion
- pancarpal arthritis

Although a variety of biomaterials are available as substitutes for bone grafting in orthopedic surgery, autogenous cancellous bone is favored as the "gold standard" for most procedures.[1–3] This is largely due to the osteoinductive, osteoconductive, and osteogenic properties of autogenous cancellous bone, as its natural scaffolding microarchitecture and proteinous growth factors facilitate vascularization and osseointegration into surrounding bone.[1,2,4]

Common donor sites for autogenous cancellous bone graft in upper extremity reconstruction include the anterior and posterior iliac crest, the ipsilateral distal radius, and the olecranon.[4] Of these, the iliac crest remains the most popular when large or corticocancellous grafts are required due to its relative ease of access and good quantity of bone graft material available.[4–7] Complications associated with harvesting from the iliac crest, however, are well reported in the

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orthopedic literature. A systematic review of 81 articles found that hematoma/seroma, chronic pain, fracture, nerve injury, and wound related complications were as high as 19.37% for iliac crest graft harvesting in 6,449 patients.[5] Additionally, injury to the lateral femoral cutaneous nerve may occur during harvesting and lead to dysesthesia in up to 10% of cases.[6] At our center, we have experienced complications with iliac crest harvesting including anterior superior iliac spine fracture, neuroma, hematoma, revision wound closure, and most commonly persistent pain.

Proximal tibia bone grafting has been reported in oral and maxillofacial surgery and foot and ankle reconstructive surgery with good volume yield and excellent clinical outcomes compared with graft harvesting from the distal tibia and greater trochanter.[4,8–10] Herford et al reported that an average of 25 mL of autogenous bone graft can be harvested from either the lateral or medial approaches to the proximal tibial metaphysis.[11] The reported complication profile compares favorably to that of iliac bone graft harvesting, with shorter pain persistence.[5,8,10] We were unable to identify reports of the use of tibial bone graft in upper extremity surgery. We report on 14 consecutive cases in which autogenous cancellous graft from the proximal tibia was harvested for use during distal radius osteotomy, radioscapholunate arthrodesis, or radiocarpal arthrodesis, and detail patient acceptance, time to union, and complications.

Methods

With Institutional Review Board approval, a retrospective review identified 14 patients (11 female, 3 male) who had undergone wrist reconstruction with autogenous cancellous bone grafting from the proximal tibia by the senior author at a single institution between 2012 and 2015. The mean age of the patients was 57 (range: 19–71) years. Of the 14 patients, 11 underwent a corrective osteotomy for a distal radius malunion, 2 patients underwent a radiocarpal arthrodesis for pancarpal arthritis following failed four-corner fusion, and 1 patient underwent a radioscapholunate fusion for posttraumatic arthritis.

Surgical Technique

Cancellous bone graft is harvested from the proximal tibia using a medial approach as described by Herford et al.[11] Although equal graft volumes are available using either the lateral or medial approach, the medial approach minimizes donor site morbidity by offering a larger surface area farther from adjacent neurovascular structures.[11,12] An oblique 2-cm incision is made 15 mm proximal and 15 mm lateral to the tibial tubercle (►**Fig. 1**). Subcutaneous dissection is carried down to the periosteum, taking care to avoid the infrapatellar branch of the saphenous nerve. The periosteum is incised and elevated, and a 0.045″ Kirschner wire is then used to outline a 1-cm circular- or oval-shaped corticotomy site, after which an osteotome is used to complete the corticotomy; the cortical cap is set aside (►**Fig. 2**). Approximately 10 to 25 mL of cancellous graft is then harvested using a curette (►**Fig. 3**).

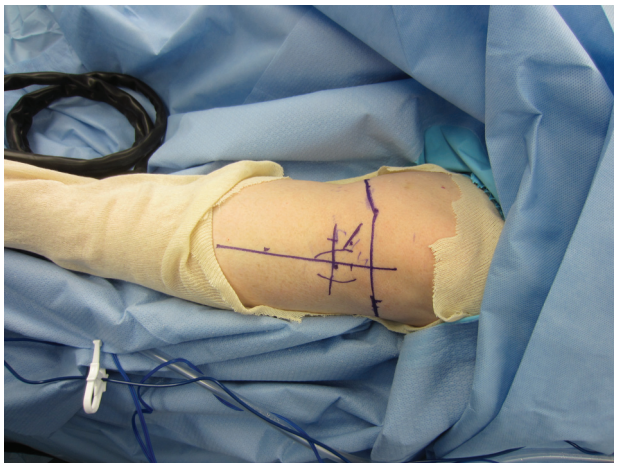

Fig. 1 The medial surface of the proximal tibia is prepared with the proper anatomic landmarks.

After successful graft harvesting, the defect is filled with thrombin-soaked Gelfoam (Pfizer, New York, NY) and the cortical cap is replaced; the periosteum is closed with 2–0 absorbable sutures, and the soft tissues are repaired with absorbable subcutaneous sutures and a pull-out skin suture.

Patients were immobilized in a short arm cast for an average of 2.8 weeks (range: 2–8 weeks), followed by a thermoplastic splint until radiographic healing. Posteroanterior oblique and lateral radiographs were performed of each wrist at 2 weeks, 6 weeks, and until radiographic union was confirmed (crossing trabeculae on three views). A single anteroposterior radiograph of the donor tibia was performed in seven patients who had discomfort at the donor site at an average of 5.4 weeks (range: 2–13) from surgery.

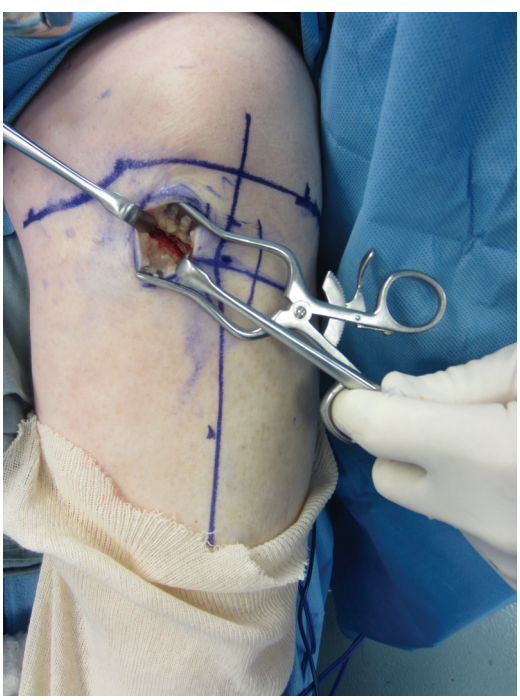

Fig. 2 The oval-shaped corticotomy site for bone graft harvesting.

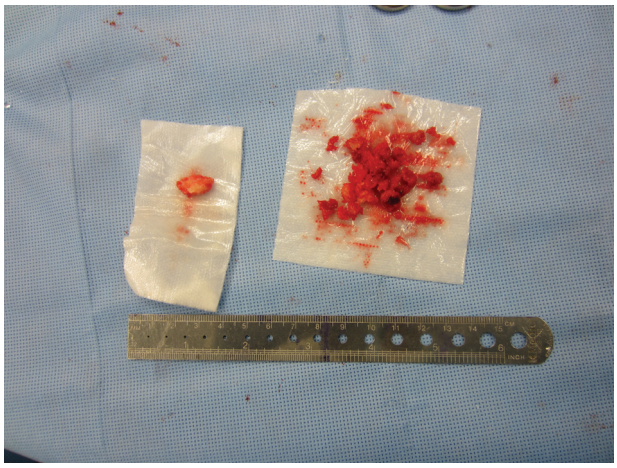

Fig. 3 Harvested bone graft material of appreciable volume.

Outcome parameters included donor limb tourniquet time, visual analog scale (VAS) from 0 to 10 (none to severe), time to radiographic union, and complications. Of the 14 patients, 10 were contacted by telephone 2 years postoperatively for the purpose of administering a subjective outcome questionnaire (►**Table 1**). All patients were asked to rate their VAS pain at the tibial graft site when symptoms were at their worst. The patients were also asked how pain at the donor site affected their ability to perform daily tasks involving ambulation when donor site pain was at its worst and currently. The extent of difficulty experienced with each activity was reported as "not at all," "a little," "a moderate amount," or "a lot."

Results

The average length of clinical follow-up was 12 months (range: 2–29.5). Of the 14 patients, 10 were reached by telephone at an average of 24.2 months (mean: 8–38 months), including the patient with only 2 months follow-up. The mean tourniquet time for the donor limb was 28 minutes (range: 20–44) (►**Table 2**). No intraoperative complications occurred during graft harvesting, and there was abundant available graft for each reconstructive indication. No patients reported any residual or persistent difficulties after the immediate postoperative pain resolved. The average time to radiographic union of the wrist was 45 (range: 34–73) days; all but one patient demonstrated clinical and radiographic healing within 6 weeks. These data are summarized in ►**Table 2**.

Complications

Radiographs of the proximal tibia demonstrated no fractures or abnormalities other than the ghost of the bone graft harvest site. One patient described transient "numbness" about the incision site, which was still present 1 year postoperatively at phone follow-up. One patient who had a history of unilateral chronic neuropathy and foot drop and thus elected preoperatively to use her "bad leg" as the donor site experienced dysesthesia and allodynia at the ipsilateral ankle 5 weeks postoperatively. A venous ultrasound study of the lower extremity was normal. The etiology of her symptoms was attributed to her neuropathy and resolved in 3 weeks without further treatment. Complications at the recipient site occurred in 2 of 14 (14%) patients and were unrelated to the graft donor site. One patient demonstrated lack of bony consolidation at 6 weeks radiographically; he had osteoporosis and was prescribed a course of Forteo (Lilly USA,

Table 1 Retrospective questionnaire

Please think back to your recuperation from the procedure that was done on your leg for the bone graft.				
What was the worst pain you had at the graft site?				
On a scale of 0 (none) to 10 (severe)? _____				
When it was at its worst, how hard was it for you to do the following activities because of the graft site?				
Activity	A lot	A moderate amount	A little	Not at all
Walking				
Going up stairs				
Going from standing to sitting				
Please answer the following questions from the point of view of how you feel now.				
How much pain do you have now at the graft site on your leg?				
On a scale of 0 (none) to 10 (severe)? ____				
How hard is it for you to do the following activities now because of the graft site on your leg?				
Activity	A lot	Moderate amount	A little	Not at all
Walking				
Going up stairs				
Going from standing to sitting				

Table 2 Patient outcomes

Case no.	Tourniquet time (min)	Time to union (d)	Follow-up time (mo)	Phone follow-up (mo)	Complications
1	21	42	6	29	None
2	43	39	20.5	21.5	None
3	20	45	5	12	Mild "numbness"
4	23	34	3	13	Transient dysesthesia, allodynia (ankle)
5	28	46	3	8	None
6	23	55	3		None
7	21	44	10	33.5	None
8	44	73	27	31	Delayed healing, ROH (wrist)
9	39	46	27	26	None
10	27	41	13		ROH (wrist)
11	27	37	6		None
12	28	42	3		None
13	25	56	29.5	29.5	None
14	29	35	2	38	None
Mean	28.4	45.4	12	24.2	

Abbreviation: ROH, removal of hardware.

LLC, Indianapolis, IN). The osteotomy healed uneventfully without any additional treatment at 73 days after surgery. Two patients complained of painful hardware (corrective osteotomy, radiocarpal arthrodesis) and hardware was removed at 105 and 30 weeks, respectively, following surgery. One of these was the patient who experienced a delayed union at the osteotomy site.

Retrospective Questionnaire

Patients recalled VAS donor site pain scores of 7.4 ± 2.7 (range: 1–10) when pain was at its worst during the immediate postoperative period. There was variability in reported pain scores, reflected by the high standard deviation of the mean score. When donor site pain was at its worst, seven patients reported no difficulty at all with walking, one reported "moderate" difficulty, and two patients reported "a lot" of difficulty. However, 8 out of the 10 patients reported moderate to high difficulty while ascending stairs or going from standing to sitting during the same period (►**Table 3**). Average donor site VAS pain score at 2 years was 0.0 (range: 0–0). No patient reported long-term donor site pain or difficulty with any activity.

Discussion

The high rate of complications associated with bone graft harvesting from the iliac crest should be of concern for upper extremity surgeons. Minor complications (superficial sensory nerve injury, hematoma, or drainage) have been reported in 7.1 to 39% of patients, while major complications (reoperation, vascular injury, permanent Trendelenburg gait, fracture, or deep infection) occur in 1.8 to 10% of patients.[4] Persistent donor site pain with a duration of more than 3 months has been reported in as many as 15% of patients.[6] Neuralgia due to compression or pinching of the lateral femoral cutaneous nerve has been reported in up to 10% of patients.[6] In contrast, the most

Table 3 Difficulty with daily activities when donor site pain was greatest

Activity	Level of difficulty, n (%)			
	A lot	A moderate amount	A little	None at all
Walking	2 (20)	1 (10)		7 (70)
Going up stairs	4 (40)	4 (40)	1 (10%)	1 (10)
Standing to Sitting	5 (50)	3 (30)		2 (20)
Doing your job	1 (10)	3 (30)		6 (60)
Participating in exercise or sports	5 (50)			5 (50)

common complications reported from harvesting proximal tibia bone graft include superficial hematoma (1.3–15%), superficial wound infection (1.3%), and immediate postoperative pain (20%).[4,10,13] Approximately 96% of patients report no residual donor site pain at an average of 28 months.[8] There have been only 10 reported cases of fracture through the donor site after proximal tibia bone graft harvesting (0.4–3.8%).[13,14] Of the 10 reported cases, 4 were treated with closed reduction, 3 with internal fixation, and 3 with cast or splint immobilization and restriction from weight-bearing.[13,14] These fractures occurred due to falls or strenuous exercise such as running or playing tennis 1 to 6 weeks postoperatively, and in one case due to school sport activity at 3 months postoperatively.[13,14] Although postoperative tibial fractures have been reported to heal without intervention,[13] some authors suggest a nonweight-bearing period of 4 to 6 weeks[10,13,14] during which patients should be cautioned to avoid excessive external pressure to the femoropatellar joint.[14]

We did not restrict weight bearing in our patients postoperatively, and none sustained a donor site fracture. We allowed unrestricted lower extremity activity at 6 weeks. In a representative sample of seven patients with postoperative tibial radiographs, we identified no bony abnormalities; thus, we do not advise routine postoperative tibial radiographs unless patients are symptomatic.

For patients who may require a larger graft volume than what is attainable from the distal radius, the iliac crest[7] is generally the default option for bone graft. It is important to note that the volume of bone graft material available from the proximal tibia is comparable to that available from the iliac crest.[9] Although histological analyses have shown that iliac crest graft contain active more hematopoietic marrow in the medullary space while tibial specimens contain more fatty marrow,[3] the two do not differ in the expression of bone morphogenetic proteins.[15] This suggests that the osteogenic and osteoconductive capacities do not differ between the two graft sites.[10] No quantitative or clinical comparative studies are available.

Due to the favorable complication profile reported in the oral–maxillofacial and foot and ankle literature, we recommended tibial bone graft harvest for wrist reconstruction in our patients. In our series, we demonstrated rapid bony healing, excellent patient compliance, and a minimal complication rate in a small, consecutive cohort of patients. The average time to radiographic union was 45 days, and only one patient experienced delayed union (10 weeks), likely secondary to intrinsic factors. There were no problems with bony healing at the donor site, and no patient experienced donor site fracture. Donor site pain did not persist for more than 2 months in any patient and in the majority of cases resolved by 4 weeks postoperatively. This compares favorably to the pain persistence profile for iliac crest harvesting. Intraoperative tourniquet times of the donor limb averaged 28 minutes, illustrating the speed, ease, and efficacy of harvesting from the proximal tibia using the described surgical technique.

Conflict of Interest
None.

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